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"A method for filtering digital images, and a filtering device"
(Menetelmä digitaalisten kuvien suodattamiseksi ja suodatin)

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A method for filtering digital images, and a filtering device

The present invention relates to a method for removing blocking related visual artefacts from a frame of a digital image, which has been coded by blocks and then decoded, in which method at least one pixel from at least one side of a block boundary is selected for filtering, filtering is performed on the block boundary between two adjacent blocks, and the blocks are scanned in a certain order. The present invention also relates to a device for removing blocking related visual artefacts from a frame of a digital image, which has been coded by blocks and then decoded, which device comprises means for selecting at least one pixel from at least one side of a block boundary for filtering, means for performing filtering on a block boundary between two adjacent blocks, and means for scanning the blocks in a certain order. The present invention also relates to an encoder, decoder, and codec comprising means for coding and decoding a digital image by blocks, which encoder comprises means for selecting at least one pixel from at least one side of a block boundary for filtering, means for performing filtering on a block boundary between two adjacent blocks, and means for scanning the blocks in a certain order. The present invention relates furthermore to a mobile terminal comprising a video codec, which comprises means for coding and decoding a digital image by blocks, which codec comprises means for selecting at least one pixel from at least one side of a block boundary for filtering, means for performing filtering on a block boundary between two adjacent blocks, and means for scanning the blocks in a certain order The present invention relates furthermore to a storage media for storing a software program comprising machine executable steps for coding and decoding a digital video signal by blocks, for selecting at least one pixel from at least one side of a block boundary for filtering, for performing filtering on a block boundary between two adjacent blocks, and for scanning the blocks in a certain order

An arrangement like the one shown in Figure 1 is generally used for transferring a digital image in compressed fom. The digital image is formed of sequential frames. In some prior art digital video transmission systems, for example ITU-T H.261/H.263 recommendations, three frame types are defined: an I-frame (Intra), a P-frame (Predicted or

Inter), and a B-frame (Bi-directional). The I-frame is generated solely on the basis of information contained in the image itself, wherein at the receiving end, this I-frame can be used to form the entire image. P-frames are formed on the basis of a preceding I-frame or P-frame, wherein at the receiving stage the preceding I-frame or P-frame is correspondingly used together with the received P-frame in order to reconstruct the image. In the composition of P-frames, for instance motion compensation is used to compress the quantity of information. B-frames are formed on the basis of one or more preceding P-frames or I-frames and/or one or more following P- or I-frames.

The frames are further divided into blocks. One frame can comprise different types of blocks. A predicted frame may also contain blocks that are not predicted. Some video coders may use the concept of independent segment decoding in which case several blocks are grouped together to form segments that are then coded independently from each other. All the blocks within a certain segment are of same type. For example, if a P-frame is composed mainly of predicted blocks and some Intra-coded blocks, the frame can be considered to comprise at least one segment of intra blocks and at least one segment of predicted blocks.

In the YUV colour model, the image is represented by a luminance component and two chrominance components. The luminance information in the image typically is transformed with full spatial resolution. Both chrominance signals are spatially subsampled, for example a field of 16 × 16 pixels is subsampled into a field of 8 × 8 pixels. The differences in the block sizes are primarily due to the fact that the eye does not discern changes in chrominance equally well as changes in luminance, wherein a field of 2 × 2 pixels is encoded with the same chrominance value.

Typically, image blocks are grouped together to form macroblocks of 2x2 blocks. The macroblock contains usually 16 pixels by 16 rows of luminance sample, the mode information, and the possible motion vectors. The macroblock is divided into four 8 x 8 luminance blocks and to two 8 x 8 chrominance blocks. Scanning (and encoding/decoding) proceeds then macroblock by macroblock conventionally from top-left

to bottom-right corner of the frame. Inside one macroblock the scanning (and encoding/decoding) order is from top-left to bottom-right corner of the macroblock.

A current video frame to be coded comes to the transmission system 10 as input data $I_n(x,y)$. In the differential summer 11 it is transformed into a prediction error frame $E_n(x,y)$ by subtracting from it a prediction frame $P_n(x,y)$ formed on the basis of a previous image. The prediction error frame is coded in block 12 in the manner described hereinafter, and the coded prediction error frame is directed to a multiplexer 13. To form a new reconstruction frame, the coded prediction error frame is also directed to a decoder 14, which produces a decoded prediction error frame $\hat{E}_n(x,y)$ which is summed in a summer 15 with the prediction frame $P_n(x,y)$, resulting in a reconstruction frame $\hat{I}_n(x,y)$. The reconstruction frame is saved in a frame memory 16. To code the next frame, the reconstruction frame saved in the frame memory is read as a reference frame $R_n(x,y)$ and in a motion compensation and prediction block 17 it is transformed into a new prediction frame $P_n(x,y)$ according to the formula

$$P_n(x,y) = R_n[x + Dx(x,y),\ y + Dy(x,y)] \qquad (1)$$

The pair of numbers $[Dx(x,y), Dy(x,y)]$ is called the motion vector of the pixel at location (x,y) and the numbers $Dx(x,y)$ and $Dy(x,y)$ are the horizontal and vertical shifts of the pixel. They are calculated in a motion estimation block 18. The set of motion vectors $[Dx(\cdot), Dy(\cdot)]$ consisting of all motion vectors related to the pixels of the frame to be compressed is also coded using a motion model comprising basis functions and coefficients. The coefficient values are coded and directed to the multiplexer 13, which multiplexes it into the same data stream with a coded prediction error frame for sending to a receiver. In this way the amount of information to be transmitted is dramatically reduced. The basis functions are known to both the encoder and the decoder. Some frames can be partly or entirely so difficult to predict using only the reference frame $R_n(x,y)$ that it is not practical to use motion compensated prediction when coding them. These frames (I-frame) or parts of frames are coded using so-called intracoding without any prediction from the reference frame $R_n(x,y)$ (I-frame), and motion vector

information relating to them is not sent to the receiver. In prior art, for I-frames or those parts of P-frames which are intra-coded, another kind of prediction may be employed, namely intra prediction. In this case, the reference is formed by the previously decoded and reconstructed blocks which are part of the same frame (or slice if independent segment decoding is used).

In the receiver system 20, a demultiplexer 21 separates the coded prediction error frames and the motion information transmitted by the motion vectors and directs the coded prediction error frames to a decoder 22, which produces a decoded prediction error frame $\hat{E}_n(x,y)$, which is summed in a summer 23 with the prediction frame $P_n(x,y)$ formed on the basis of a previous frame, resulting in a decoded frame $\hat{I}_n(x,y)$. The decoded frame is directed to an output 24 of the decoder and at the same time saved in a frame memory 25. When decoding the next frame, the frame saved in the frame memory is read as a reference frame $R_n(x,y)$ and transformed into a new prediction frame in the motion compensation and prediction block 26, according to formula (1) presented above.

The coding method applied in block 12 and 29 to the coding of the prediction error frame or to the intracoding of a frame or part of a P-frame to be sent without prediction, is generally based on a transformation, the most common of which is Discrete Cosine Transformation, DCT. The frame is divided into adjacent blocks sized e.g. 8 x 8 pixels. The transformation is calculated for the block to be coded, resulting in a series of terms. The coefficients of these terms are quantized on a discrete scale in order that they can be processed digitally. Quantization causes rounding errors, which can become visible in an image reconstructed from blocks so that there is a discontinuity of pixel values at the boundary between two adjacent blocks. Because a certain decoded frame frame (or for the case of intra prediction a certain previously coded area) is used for calculating the prediction frame for the next frames, the errors can be propagated in sequential frames, thus causing visible edges in the image reproduced by the receiver. Image errors of this type are called blocking artefacts. In predicted intracoded areas the blocking artefacts typically lead to

other types of visual artefacts which are specific to the type of intra prediction used. ,

The principles presented above are also applicable to a situation where segmented frames are used. In that case the coding and decoding is performed in segments of the frame according to the type of the blocks in each segment.

Some prior art methods are known for removing blocking artefacts. These methods are characterized by the following features:

- determining which pixel requires value correction in order to remove the blocking artefact,

- determining a suitable low-pass filtering for each pixel to be corrected, based on the values of other pixels contained by a filtering window placed around the pixel,

- calculating a new value for the pixel to be corrected, and

- rounding the new value to the closest digitized pixel value.

Factors that influence the selection of a filter and the decision to introduce a filter can be, for example, the difference between the values of pixels across the block boundary, the size of the quantization step of the coefficients received as the transformation result, and the difference of the pixel values on different sides of the pixel being processed.

In prior art methods the filtering of blocking and other types of visual artefacts is performed frame by frame, *i.e.* the whole frame is first decoded and then filtered. As a result, the effects of blocking artefacts easily propagate within a frame or from one frame to the next when prior art methods are used and especially in predictive intracoding.

It has been found that prior art methods also tend to remove lines of the image that should really be part of it. On the other hand, prior art methods are not always capable of removing all blocking blocking or blocking related artefacts.

A primary object of the method according to the invention is to limit the propagation of blocking artefacts within frames and from one frame to the next. Another objective of the present invention is to present a new kind of filtering arrangement for removing blocking and other blocking related artefacts which are especially visible when predictive intracoding is used. The invention also has the objective that the method and device according to it operate more reliably and efficiently than prior art solutions.

The objectives of the invention are achieved by performing the filtering in a particular order and substantially immediately after an image block is decoded and there is at least one block boundary available to be filtered. Among other things this provides the advantage that effects of blocking blocking and other visual artefacts are not spread over the whole frame (*i.e.* to limit spatial and temporal propagation of blocking artefacts). Furthermore, the results of previous block boundary filtering operations can be utilised in the coding, decoding and filtering of the next block boundary. In other words, pixel values modified/corrected in connection with the filtering of one boundary are then available for use when coding, decoding and filtering other block boundaries.

The method according to the invention for removing blocking and other visual artefacts (which are mainly caused by blocking artefacts) from a frame that has been coded by blocks, is characterized in that filtering on the block boundary is performed substantially immediately after the block is decoded, and that the order of filtering the boundaries is predetermined.

The invention also relates to a device for implementing the method according to the invention. The device according to the invention is characterized in that filtering on the block boundary has been performed substantially immediately after the block is decoded, and that the order of filtering the boundaries has been predetermined.

The encoder according to the invention is characterized in that filtering on the block boundary has been performed substantially immediately after the block is decoded, and that the order of filtering the boundaries

has been predetermined. The decoder according to the invention is characterized in that filtering on the block boundary has been performed substantially immediately after the block is decoded, and that the order of filtering the boundaries has been predetermined. The codec according to the invention is characterized in that filtering on the block boundary has been performed substantially immediately after the block is decoded, and that the order of filtering the boundaries has been predetermined.

The decoder according to the invention is characterized in that filtering on the block boundary has been performed substantially immediately after the block is decoded, and that the order of filtering the boundaries has been predetermined.

The codec according to the invention is characterized in that filtering on the block boundary has been performed substantially immediately after the block is decoded, and that the order of filtering the boundaries has been predetermined.

The mobile terminal according to the invention is characterized in that filtering on the block boundary has been performed substantially immediately after the block is decoded, and that the order of filtering the boundaries has been predetermined.

The strorage media according to the invention is characterized in that the software program further comprises machine executable steps for performing filtering on the block boundary substantially immediately after the block is decoded, and that the order of filtering the boundaries has been predetermined.

Because blocking artefacts occur at block boundaries, the filtering method according to the invention is only applied to pixels at block boundaries and the immediate vicinity thereof. Edges that are part of the image can reside anywhere in the image area. In order that only pixels containing blocking artefacts are selected for corrective filtering and that the quality of edges that are part of the image is not affected during filtering, the following assumptions have been made in the study that resulted in the invention:

The changes in pixel value associated with in edges that are part of the image, the pixel value change is generally larger than those associated with blocking artefacts, and

Those edges within the image, where the pixel value change is small do not suffer considerably from the rounding of the pixel value difference caused by filtering.

Because the image to be coded is generally divided into blocks both vertically and horizontally, the image contains both vertical and horizontal block boundaries. With regard to vertical block boundaries, there are pixels to the right and left of the boundary, and with regard to horizontal block boundaries, there are pixels above and below the boundary. In general, the location of the pixels can be described as being on a first or a second side of the block boundary. In the filtering according to the invention, the.

The method and associated device according to the invention significantly limits propagation of visual anomalities due to blocking artefacts from previously reconstructed blocks to subsequently reconstructed blocks within the same frame, or within the same segment, if independent segment decoding is used. Propagation of blocking artefacts within frames and from one frame to the next is also reduced. By using the method and device according to the invention a larger number of blocking and blocking related artefacts can be removed without weakening the real image edges unreasonably.

In the following, the invention will be described in more detail with reference to the preferred embodiments and the accompanying drawings, in which

Figure 1 represents a prior art digital video codec,

Figure 2 represents an advantageous block scanning order in the method according to a preferred embodiment of the invention,

Figure 3 represents an advantageous block boundary filtering order after reconstruction of a block according to a preferred embodiment of the invention,

Figure 4 represents an advantageous filtering order in the preferred method according to the invention,

Figure 5 represents a digital image block transfer system for implementing a method according to the invention,

Figure 6 represents a flow diagram of a method according to the invention, and

Figure 7 is a schematic representation of a portable teleconferencing device implementing a method according to the invention.

In the following description of the invention and its preferred embodiments, reference will be made mostly to Figures 2 to 6. The same reference numbers are used for corresponding parts in the figures as in connection with the description of Figure 1.

In the following, the operation of the decoder is described. The scanning order used in the encoder and decoder are the same, *i.e.* known to both encoder and decoder. However, the particular scanning order chosen is not essential for implementation of the method according to the invention. Figure 2 shows an advantageous scanning order of a frame comprising groups of blocks, *e.g.* macroblocks. First, the top-left block B1 is decoded, *i.e.* pixel values representing *i.e.* the luminance information of the block are reconstructed and saved into frame buffer. Then, the top-right block B2 is decoded and saved into frame buffer. Now, the first vertical boundary R11 between the top-left block B1 and top-right block B2 has a decoded block at both sides, so the boundary R11 can be filtered. Advantageously only those pixel values which are changed by the filtering are updated in the frame buffer. There are many known methods for performing filtering on the block boundary. One prior art filtering method which can be implemented with the invention is disclosed in international patent publication WO 98/41025 which is to be considered as a reference here.

Next, the bottom-left block B3 of the group of blocks in question is decoded and saved into frame buffer. Now, the first horizontal boundary R13 between the top-left block B1 and bottom-left block B3 has a decoded block on both sides, wherein the first horizontal boundary R13 can also be filtered. In the filtering of the first vertical boundary R12 some pixel values near the first horizontal boundary R13 may have changed. Advantageously, these modified values are used in the filtering of the first horizontal boundary R12. This helps to further restrict propagation of visual artefacts from previously reconstructed blocks to subsequent reconstructed blocks within the same frame, or same segment, if independent segment decoding is used.

Now the fourth block B4 inside the macroblock is decoded and saved into frame buffer. When the decoding of the fourth block B4 is complete there exist two additional boundaries having a decoded block on either side: the second vertical boundary R34 and the second horizontal boundary R24. Therefore, both of said boundaries R34, R24 can now be filtered. In this advantageous embodiment of the method according to the invention the filtering is done such that the second horizontal boundary R24 is filtered first, the filtering result is saved in the frame buffer, and the second vertical boundary R34 is filtered subsequently. In a general case, if two boundaries (*e.g.* to the left of and above) a current block are filtered then the changed pixel values resulting from the first filtered boundary are used when filtering the other boundary.

In an advantageous embodiment of the invention, for a certain block, filtering can be performed across one, two, three, four, or none of the boundaries of the block, depending on which scanning order is adopted for coding the blocks inside a frame, or segment. In the preferred mode of implementation the order in which blocks are reconstructed is illustrated in Figure 2. As depicted, four blocks are grouped together to form macroblocks of 2x2 blocks. Scanning proceeds then macroblock by macroblock from the top-left to the bottom-right corner of the frame. Inside one macroblock the order is from top-left to bottom-right corner of the macroblock. Due to this particular scanning order, in the preferred mode of implementation a maximum of two boundaries (to the left of and/or above) a block become available for filtering, when a block

is reconstructed. The order in which block boundaries are advantageously examined for filtering is illustrated in Figure 3 (left boundary first and then the upper one). The remaining boundaries, i.e. to the right and below, are filtered only when reconstruction of an adjacent block to the right and, respectively, below is completed. In the event that the block is located at the frame border or at a segment border, the corresponding block boundary/boundaries is/are not filtered since there is no adjacent block to filter across the common boundary. In the preferred mode of implementation the order in which the block boundaries are filtered inside one frame is illustrated in Figure 4 for a small frame size of 6x4 blocks. The numbers on the block boundaries represent the filtering order according to an advantageous embodiment of the present invention. In practical applications the frame typically comprises more than 6x4 blocks, but it is clear from the description above how the preferred filtering order can be extended to frames and segments which comprise more (or less) than 6x4 blocks.

In general, the system described in this invention can be applied to block-based still image coding as well as to all kinds of coding in block-based video coders: I, P, B, coded and not-coded. The filtering described in this invention works for a frame that is divided into NxM blocks for coding.

In the method described in this invention report as soon as a block is reconstructed, filtering is applied only across those block boundaries that are adjacent to other previously reconstructed blocks. In case of independent segment decoding, the filtering is only applied across those block boundaries that are adjacent to previously reconstructed blocks belonging to the same segment as current block.

An essential feature of the method according to the invention is the fact that the result of filtering is made available to the digital image coding system before reconstructing a subsequent block in the frame. This is especially advantageous for predictive intracoding where prediction of a block is done by using texture of prior reconstructed block inside the same frame (or segment, if independent segment decoding is utilised). The current scheme is also advantageous for any given block coding scheme which uses prediction of a block from previously reconstructed

blocks inside the same frame or the same segment. In addition to the advantages achieved by prior art solutions, this way of operation prevents propagation of visual artefacts from previously reconstructed blocks to subsequent reconstructed blocks within the same frame, or the same segment, if independent segment decoding is used. Reconstruction of a certain block is therefore dependent on filtered data derived from previously reconstructed blocks. In order to avoid encoder-decoder mismatch, the decoder not only has to execute exactly same scheme of filtering but also has to perform filtering operations in exactly same order as the decoder part of the encoder does. The method also prevents propagation of blocking artefacts from one frame to the next, because blocking artefacts in a frame used *e.g.* in prediction are reduced by the method according to the invention.

In the following, the transmission and reception of video frames in a video transmission system is described with reference to the image transfer system presented in Figure 5 and the flow diagram in Figure 6. The blocks of the frame are directed one by one to the block transfer arrangement presented in Figure 5. The current current block in the frame comes to the transfer system 50 as input data. The frame is received from a digital image source *e.g.* a camera or a video recorder (not shown) at an input 27 of the image transfer system. The frame can temporarily be stored in a frame memory (not shown), or the image transfer system 50 receives the input data directly block by block. The blocks of the frame are directed one by one to the differential summer 28, where every block is transformed into a prediction error block by subtracting from it a respective intra predicted block of the prediction frame formed on the basis of previously reconstructed blocks inside the current image. The prediction error block is coded in encoder 29. At the beginning of the encoding of the frame *e.g.* the first block B1 is coded.

The coded prediction error block is directed to the multiplexer 13. In order to form a new prediction block, the coded prediction error block is also directed to a decoder 30, which produces a decoded prediction error block which is summed in summer 31 with the respective prediction block of the prediction frame produced by prediction block 34, resulting in a decoded block. The prediction block 34 receives input from a frame buffer 33, where all the preceding reconstructed blocks

inside the current frame are stored, and the prediction estimation block 35, which, in turn, receives input from both the input 27 and the frame buffer 33.

The decoded block is directed to the block boundary filter 32. Furthermore, the block boundary filter 32 examines 602, 603 if there exist block boundaries of the present block, which can be filtered. If more than one such boundary is found, the block boundary filter 32 determines 604 the filtering order of the boundaries. If at least one such boundary is found, the block boundary filter 32 performs the filtering 606 and updates 607 at least the modified pixel values in the frame buffer 33. Prior to filtering the boundary, the block boundary filter 32 retrieves 605 from the frame buffer 33 such pixel values which belong to the adjacent block of the present boundary and which will be used in the filtering process. Then, the block boundary filter 32 examines 608 if there still are boundaries to be filtered. If there are boundaries to be filtered, the process returns to step 605, otherwise filtering is applied to the next block and so on until all blocks have been processed.

In the receiver 60, the demultiplexer 21 separates the coded prediction error blocks and the prediction information transmitted by the motion vectors and directs the coded prediction error blocks to the decoder 36, which produces a decoded prediction error block, which is summed in summer 37 with the respective intra prediction block of the prediction frame formed on the basis of previous reconstructed blocks inside current frame/slice, resulting in a decoded block. It is directed to the block boundary filter 38.

The steps of the block boundary filter 32 in the transmission system 50 are also applicable in the block boundary filter 38 of the receiver 60. Therein, the block boundary filter 38 examines 602, 603 if there exist block boundaries of the present block, which can be filtered. If more than one such boundary is found, the block boundary filter 38 determines 604 filtering order of the boundaries. If at least one such boundary is found, the block boundary filter 38 performs filtering 606 and updates 607 at least the modified pixel values in the receiver frame buffer 39. If necessary, prior to filtering the boundary, the block boundary filter 38 retrieves 605 from the receiver frame buffer 39 such

pixel values which belong to the adjacent block of the present boundary and which will be used with filtering process. Then, the block boundary filter 38 examines 608 if there still are boundaries to be filtered. If there are boundaries to be filtered, the process returns to step 605, otherwise filtering is applied to the next block and so on until all blocks have been processed.

Blocks of the decoded frame can be directed to the output 40 of the receiving decoder either substantially immediately after each block is decoded, or after the whole frame has been decoded.

The block carrying out filtering method according to the invention is particularly advantageously implemented in a digital signal processor or a corresponding general purpose device suited to processing digital signals, which can be programmed to apply predetermined processing functions to signals received as input data. The measures according to Figure 6 can be carried out in a separate signal processor or they can be part of the operation of such a signal processor which also contains other arrangements for signal processing.

A storage media can be used for storing a software program comprising machine executable steps for performing the method according to the invention. Then in an advantageous embodiment of the invention the software program can be read from the storage media to a device comprising programmable means, *e.g.* a processor, for performing the method of the invention.

In the method and device according to the invention, the number of the pixels to be selected for filtering can vary, and it is not necessarily the same on different sides of the block boundary. The number of pixels may be adapted according to the general features of the image information contained by the frame. Furthermore, many filtering methods can be applied with the present invention. In some intra-prediction methods it is not necessary to send the intra prediction information in addition to the coded differential blocks to the receiver 60.

The invention can be modified without departing from the scope defined by the claims hereinafter, using the capabilities of a person skilled in

the art without actual inventive steps. The definitions of filtering order above have also been intended as examples only. A particularly advantageous use of the invention is in mobile teleconferencing applications, digital television receivers and other devices that at least receive and decode digital video image.

A mobile terminal 41 intended for use as a portable teleconferencing device and applying the deblocking filter method according to the invention comprises advantageously at least display means 42 for displaying images, audio means 43 for audio information, keyboard 44 for inputting *e.g.* user commands, radio part 45 for communicating with mobile network, processing means 46 for controlling the operation of the device, memory means 47 for storing information, and preferably a camera 48 for taking images.

The present invention is not solely restricted to the above presented embodiments, but it can be modified within the scope of the appended claims.

Claims:

1. A method for removing blocking related visual artefacts from a frame of a digital image, which has been coded by blocks (B1, B2, B3, B4) and then decoded, in which method at least one pixel from at least one side of a block boundary (R12, R13, R24, R34) is selected for filtering, filtering is performed on the block boundary (R12, R13, R24, R34) between two adjacent blocks (B1, B2, B3, B4), and the blocks are scanned in a certain order, **characterized** in that filtering on the block boundary (R12, R13, R24, R34) is performed substantially immediately after the block (B1, B2, B3, B4) is decoded, and that the order of filtering the boundaries is predetermined.

2. A method according to Claim 1, **characterized** in that after a block (B1, B2, B3, B4) is decoded it is examined (603, 604) to determine, if there exists another decoded block (B1, B2, B3, B4) adjacent to said decoded block under examination, wherein if such a block is found, filtering is performed on the boundary (R12, R13, R24, R34) between said decoded block under examination and said another decoded block.

3. A method according to Claim 2, **characterized** in that if there exists more than one decoded block (B1, B2, B3, B4) adjacent to said decoded block under examination, filtering is performed in a certain order on the boundaries (R12, R13, R24, R34) between said decoded block under examination and said other decoded blocks.

4. A method according to Claim 2 or 3, **characterized** in that a value of at least one pixel selected for examination is corrected by filtering, and that at least corrected values of filtered pixels are used in filtering on other block boundaries (R12, R13, R24, R34).

5. A method according to Claim 2, 3 or 4, **characterized** in that the blocks of the frame are grouped into macroblocks, wherein the frame is scanned macroblock by macroblock.

6. A method according to Claim 5, **characterized** in that the frame is scanned horizontally from top-left to bottom-right.

7. A method according to Claim 6, **characterized** in that in a situation where at least two boundaries are filtered after the block (B4) is decoded, the filtering order is selected such that the left boundary (R34) of said block is filtered before the top boundary (R24).

8. A device for removing blocking related visual artefacts from a frame of a digital image, which has been coded by blocks (B1, B2, B3, B4) and then decoded, which device comprises means for selecting at least one pixel from at least one side of a block boundary (30) for filtering, means for performing filtering on a block boundary (R12, R13, R24, R34) between two adjacent blocks (B1, B2, B3, B4), and means for scanning the blocks in a certain order, **characterized** in that filtering on the block boundary (R12, R13, R24, R34) has been performed substantially immediately after the block (B1, B2, B3, B4) is decoded, and that the order of filtering the boundaries has been predetermined.

9. A device according to Claim 8, **characterized** in that it comprises means for determining, if there exists another decoded block (B1, B2, B3, B4) adjacent to said decoded block under examination.

10. A device according to Claim 9, **characterized** in that the means for performing filtering on a block boundary (R12, R13, R24, R34) comprises means for performing the filtering in a certain order on the boundaries (R12, R13, R24, R34) between said decoded block under examination and said other decoded blocks.

11. A device according to Claim 9 or 10, **characterized** in that it comprises a filter for correcting a value of at least one pixel selected for examination, means for saving the results of filtering on a block boundary (R12, R13, R24, R34), and means for using the saved results in filtering on other block boundaries (R12, R13, R24, R34).

12. A device according to Claim 9, 10 or 11, **characterized** in that the blocks of the frame have been grouped into macroblocks, wherein the frame is arranged to be scanned macroblock by macroblock.

13. A device according to Claim 12, **characterized** in that the frame has been scanned horizontally from top-left to bottom-right.

14. A device according to Claim 13, **characterized** in that the filtering order has been selected such that the left boundary (R34) of said block is filtered before the top boundary (R24).

15. An encoder (50) comprising means for coding and decoding a digital image by blocks (B1, B2, B3, B4), which encoder comprises means for selecting at least one pixel from at least one side of a block boundary (30) for filtering, means for performing filtering on a block boundary (R12, R13, R24, R34) between two adjacent blocks (B1, B2, B3, B4), and means for scanning the blocks in a certain order, **characterized** in that filtering on the block boundary (R12, R13, R24, R34) has been performed substantially immediately after the block (B1, B2, B3, B4) is decoded, and that the order of filtering the boundaries has been predetermined.

16. A decoder (60) comprising means for coding and decoding a digital image by blocks (B1, B2, B3, B4), which decoder comprises means for selecting at least one pixel from at least one side of a block boundary (30) for filtering, means for performing filtering on a block boundary (R12, R13, R24, R34) between two adjacent blocks (B1, B2, B3, B4), and means for scanning the blocks in a certain order, **characterized** in that filtering on the block boundary (R12, R13, R24, R34) has been performed substantially immediately after the block (B1, B2, B3, B4) is decoded, and that the order of filtering the boundaries has been predetermined.

17. A codec (50, 60) comprising means for coding and decoding a digital image by blocks (B1, B2, B3, B4), which codec comprises means for selecting at least one pixel from at least one side of a block boundary (30) for filtering, means for performing filtering on a block boundary (R12, R13, R24, R34) between two adjacent blocks (B1, B2, B3, B4), and means for scanning the blocks in a certain order, **characterized** in that filtering on the block boundary (R12, R13, R24, R34) has been performed substantially immediately after the block (B1, B2, B3, B4) is decoded, and that the order of filtering the boundaries has been predetermined.

18. A mobile terminal comprising a video codec (50, 60), which comprises means for coding and decoding a digital image by blocks

(B1, B2, B3, B4), which codec comprises means for selecting at least one pixel from at least one side of a block boundary (30) for filtering, means for performing filtering on a block boundary (R12, R13, R24, R34) between two adjacent blocks (B1, B2, B3, B4), and means for scanning the blocks in a certain order, **characterized** in that filtering on the block boundary (R12, R13, R24, R34) has been performed substantially immediately after the block (B1, B2, B3, B4) is decoded, and that the order of filtering the boundaries has been predetermined.

19. A storage media for storing a software program comprising machine executable steps for coding and decoding a digital video signal by blocks, for selecting at least one pixel from at least one side of a block boundary (30) for filtering, for performing filtering on a block boundary (R12, R13, R24, R34) between two adjacent blocks (B1, B2, B3, B4), and for scanning the blocks in a certain order, **characterized** in that the software program further comprises machine executable steps for performing filtering on the block boundary (R12, R13, R24, R34) substantially immediately after the block (B1, B2, B3, B4) is decoded, and that the order of filtering the boundaries has been predetermined.

L3

Abstract:

The invention relates to a method for removing blocking and other blocking related visual artefacts from the frame of a digital image, which has been coded by blocks (B1, B2, B3, B4) and then decoded. In the method at least one pixel from at least one side of a block boundary (R12, R13, R24, R34) is selected for filtering. Filtering is performed on the block boundary (R12, R13, R24, R34) between two adjacent blocks (B1, B2, B3, B4). The blocks are scanned in a certain order. Filtering on the block boundary (R12, R13, R24, R34) is performed substantially immediately after the block (B1, B2, B3, B4) is decoded, and the order of filtering the boundaries is determined.

Fig. 4

L 4

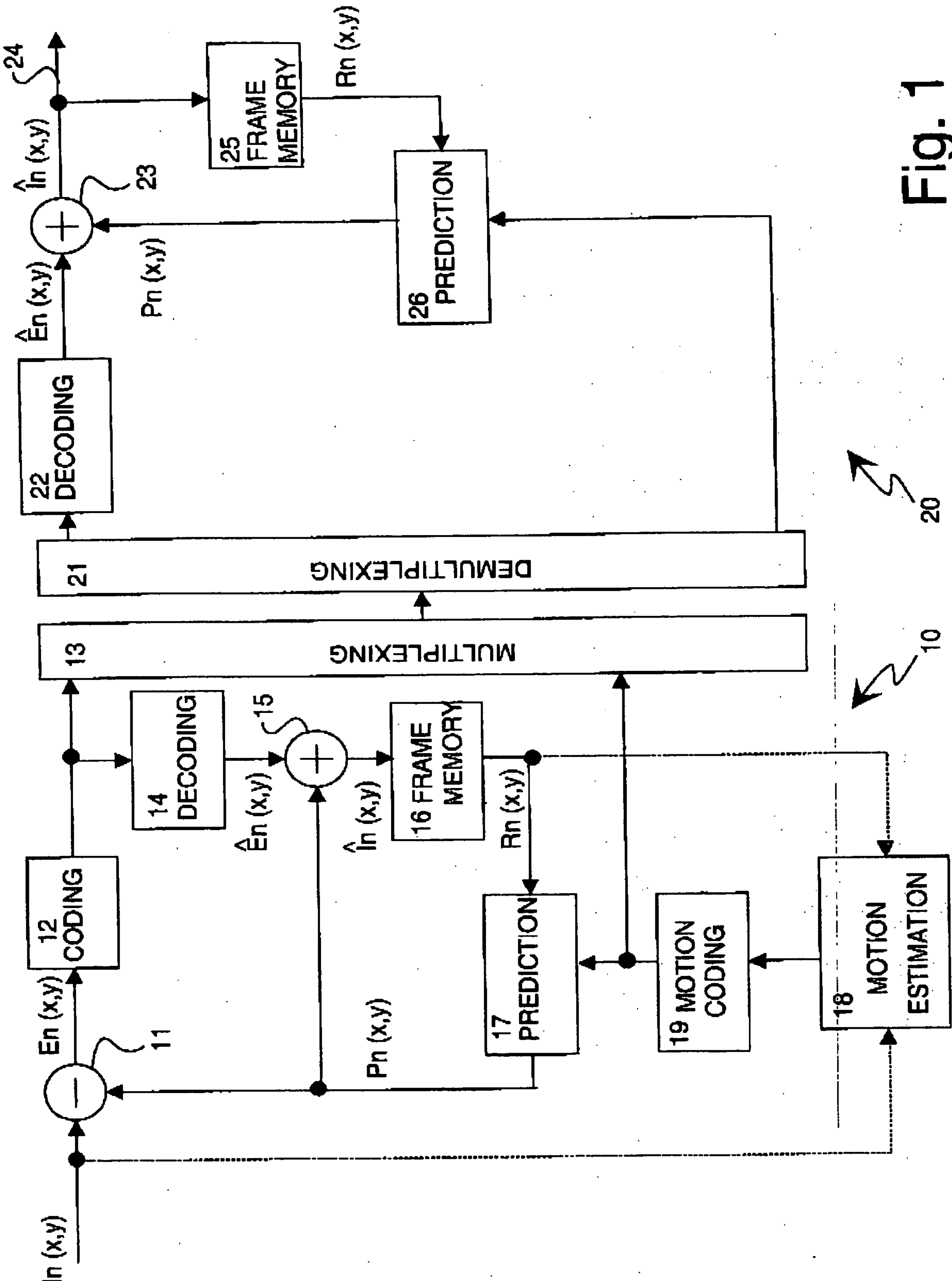
In (x,y)
11
En (x,y)
12 CODING
13 MULTIPLEXING
14 DECODING
Ên (x,y)
15
În (x,y)
16 FRAME MEMORY
Rn (x,y)
17 PREDICTION
Pn (x,y)
19 MOTION CODING
18 MOTION ESTIMATION
10
21 DEMULTIPLEXING
22 DECODING
Ên (x,y)
23
Pn (x,y)
În (x,y)
24
25 FRAME MEMORY
Rn (x,y)
26 PREDICTION
20

Fig. 1

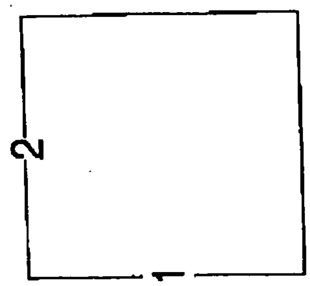
2
1

Fig. 3

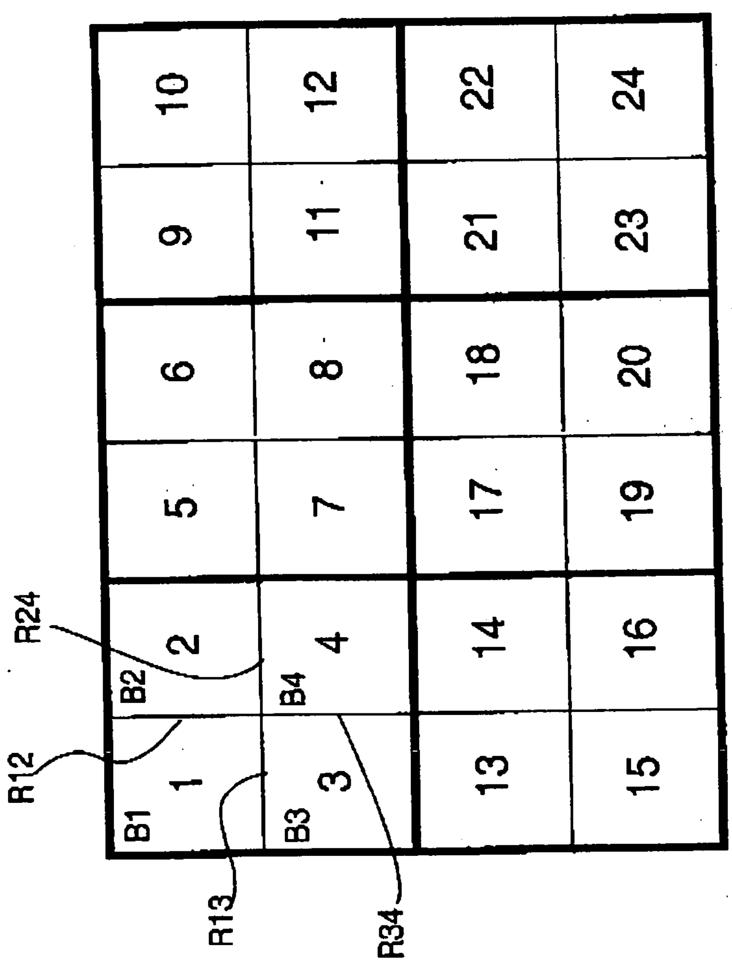
R24
R12
R13
R34
B1
B2
B3
B4
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

Fig. 2

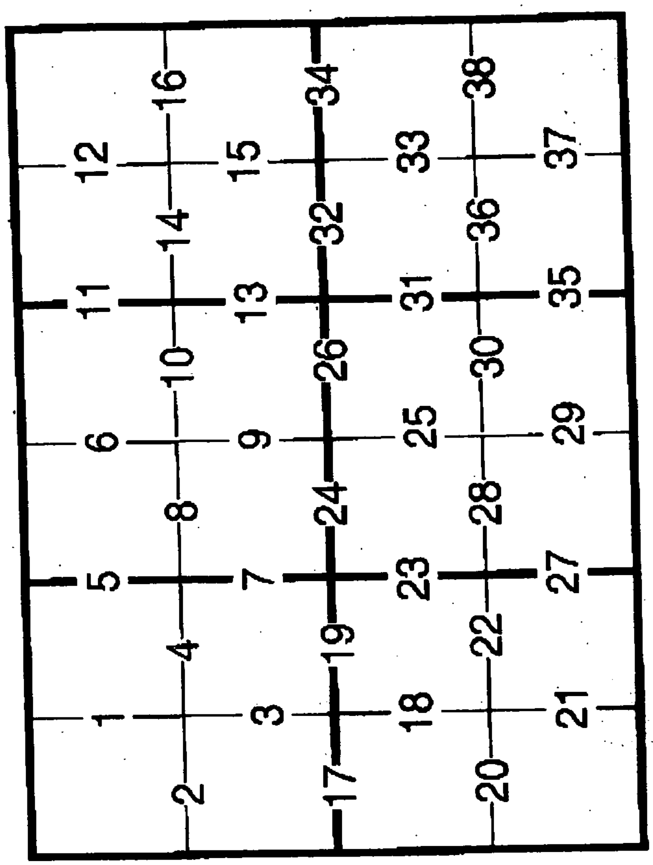
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38

Fig. 4

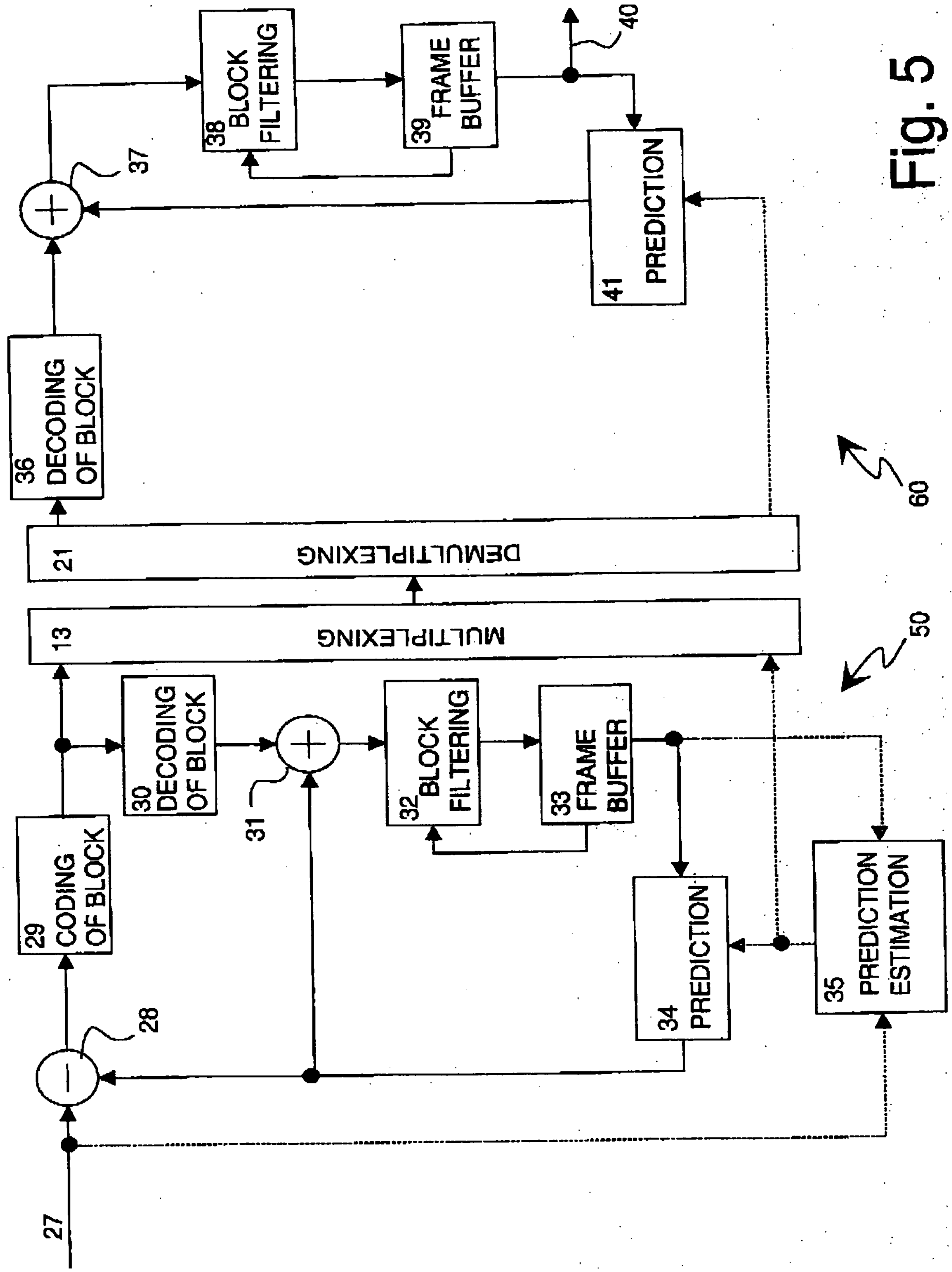
27
28
29 CODING OF BLOCK
30 DECODING OF BLOCK
31
32 BLOCK FILTERING
33 FRAME BUFFER
34 PREDICTION
35 PREDICTION ESTIMATION
13 MULTIPLEXING
50
21 DEMULTIPLEXING
60
36 DECODING OF BLOCK
37
38 BLOCK FILTERING
39 FRAME BUFFER
40
41 PREDICTION

Fig. 5

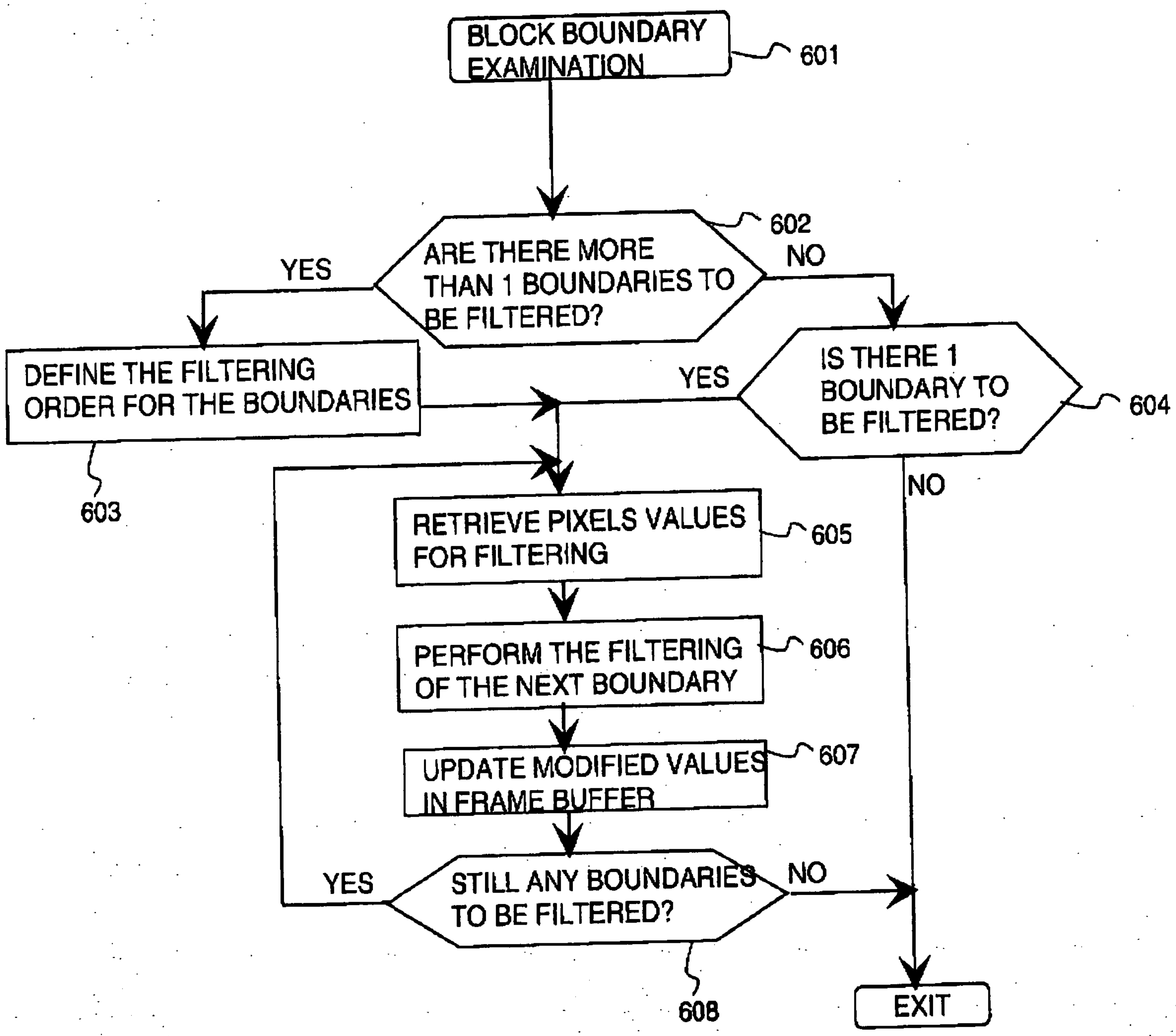
BLOCK BOUNDARY EXAMINATION
601
ARE THERE MORE THAN 1 BOUNDARIES TO BE FILTERED?
602
YES
NO
DEFINE THE FILTERING ORDER FOR THE BOUNDARIES
603
IS THERE 1 BOUNDARY TO BE FILTERED?
604
YES
NO
RETRIEVE PIXELS VALUES FOR FILTERING
605
PERFORM THE FILTERING OF THE NEXT BOUNDARY
606
UPDATE MODIFIED VALUES IN FRAME BUFFER
607
STILL ANY BOUNDARIES TO BE FILTERED?
608
YES
NO
EXIT

Fig. 6

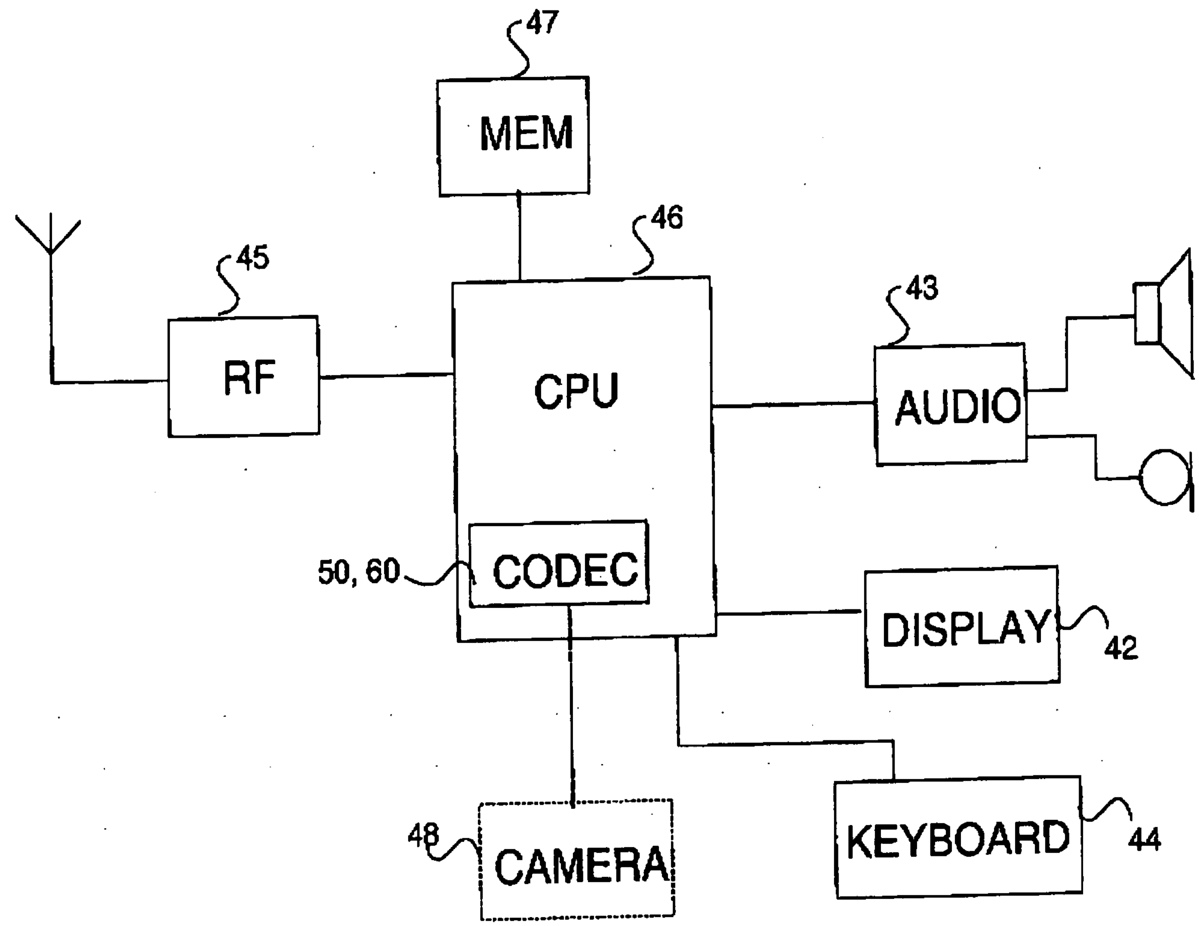
47
MEM
46
45
RF
CPU
43
AUDIO
CODEC
50, 60
DISPLAY
42
48
CAMERA
KEYBOARD
44

Fig. 7